EXHIBIT I

Abhilash Jindal

COL733 Cloud computing technology fundamentals

2021-2022 Sem II

This course introduces cloud infrastructure. Students should feel more comfortable with building and deploying their cloud services after having done this course.

Course Information

- **Prerequisites**: COL331 or equivalent.

  Note: The course includes programming assignments and thus expects proficiency with systems programming and debugging.

- **Credits**: 3-0-2
- **Slot**: AB, Mondays and Thursdays 3:30-4:45pm in MS Teams.
- **TAs**:
  - Nutesh Sahu: jcs212242 AT csia.iitd.ac.in
  - Soumen Basu: soumen.basu AT cse.iitd.ac.in
  - Abhisek Panda: csz202445 AT cse.iitd.ac.in
- **TA Office hours**: TBD
- **Reading material**: There is no textbook for the course. Most lectures will link to more reading material.

Grading criteria

- 30% labs (programming assignments)
- 20% project
- 10% assignments
- 20% minor exam
- 20% major exam

Supporting systems

- **Lectures** will be held in the course Teams channel.
- **Assignments** will be regularly released on gradescope.
- **Labs** are to be done on Baadal. You will need VPN access to IITD network!
- **Discussions** should be done on Piazza.

Acknowledgements

Thanks to Robert T. Morris, MIT and Mythilli Vutukuru, IITB; parts of this course have been inspired by courses made available by them.

Policies

Audit criteria

30% or more marks.

Ethics

We will employ various methods to catch cheating. Cheating in labs/assignments will bring zero in that lab/assignment.

Late policy

- To help you cope with unexpected emergencies, you can hand in your Labs solutions late, but the total amount of lateness summed over all the lab deadlines must not exceed 72 hours. You can divide up your 72 hours among the labs however you like; you don't have to ask or tell us. You can only use late hours only for Labs.
- Assignments can not be submitted late. 1 assignment in the course can be skipped without penalty.
- **COVID addendum**: In case you're affected with an illness, including COVID-19, you can send upto 1 assignment late by 1 week and upto 1 lab late by 1 week by emailing Soumen. Please attach a proof of illness in the email. This can only be used once in the semester and does not affect the other late policy. In other words, in addition to the 1 1-week late assignment, another assignment can be skipped without penalty. Similarly, 3-day extension can be used for the other two labs.

Tentative topics

- Virtualization: containers, orchestration, hypervisors
- Recoverability: journaling, snapshotting
- Fault tolerance: state transfer, replicated state machines
- Consistency and availability: PACELC theorem
- Storage Scalability: sharding, consistent hashing
- Cloud programming: dataflow computation, pub-sub, locking, transactions
- Light coverage of other topics: cloud economics, public cloud offerings, security

While discussing these topics, we plan to study popular cloud offerings: containers such as docker, orchestration in k8s, key-value stores such as Redis, co-ordination service such as Zookeeper, SQL/NoSQL databases, distributed file systems such as HDFS, pub-sub system Kafka, and dataflow computation in Spark.

> *Disclaimer: Actual course contents may differ slightly depending on student interest. Reach out to the instructor as soon as possible if there is a particular interest in a topic.*

Tentative Schedule

Week	Monday	Thursday	Sunday
1	3 Jan **LEC 1: Introduction.**	6 Jan **LEC 2: What is scalability? Task DAGs**. Ch.5 of Introduction to Parallel Computing	
2	10 Jan **LEC 3: Fault-tolerant embarrasingly parallel programs.** MapReduce	13 Jan **LEC 4: Work pool model. Introduce Lab 1.** Celery Optional: Celery at Instagram	
3	17 Jan **LEC 5: Struggles with Distributed shared memory.** DSM survey.	20 Jan **LEC 6: Resilient Distributed Datasets.** Spark.	23 Jan **Lab 1 DUE**

Week	Monday	Thursday	Sunday
4	24 Jan **LEC 7: Streaming computation as mini-batches.** Spark streaming.	27 Jan **LEC 8: Real-time stateful streaming (Flink). Introduce Lab 2.** Lightweight Asynchronous Snapshots. Redis streams.	
5	31 Jan **LEC 9: Large-scale ML.** TensorFlow	3 Feb **LEC 10: Google file system.** GFS	6 Feb **Lab 2 DUE**
6	7 Feb **LEC 11: Revisit cycles in real-time stateful streaming. Introduce projects.** Lightweight Asynchronous Snapshots	10 Feb **LEC 12: Amazon Dynamo: Decentralization.** Dynamo, Gossip protocol in cassandra	
7	14 Feb ==Minors==	17 Feb ==Minors==	20 Feb **Project proposal DUE**
8	21 Feb **LEC 13: Amazon Dynamo: Eventual consistency. Introduce Lab 3.** Dynamo, CRDT	24 Feb **LEC 14: Replicated state machines, leader election in Raft**. Raft	
9	28 Feb ==Semester break==	3 Mar **LEC 15: Other safety properties in Raft. Linearizability.** Raft	6 Mar **Lab 3 DUE**
10	7 Mar **LEC 16: Improve read throughput, give up on linearizability of reads.** Zookeeper	10 Mar **LEC 17: Distributed transactions. Serializability, 2-phase commit.**	
11	14 Mar **LEC 18: OS background for virtualization.** OS book	17 Mar **LEC 19: Popek-Goldberg theorem. CPU/memory Paravirtualization in Xen.**	
12	21 Mar Instructor affected by viral. Makeup class on Apr 2.	24 Mar **LEC 20: I/O virtualization.** Parts of VMWare paper	27 Mar **Project DUE**
13	28 Mar **Project presentations** Self-study: Containers: Lec 11	31 Mar **Project presentations** Self-study: Containers: Lec 11	2 Apr **LEC 21: Hardware assisted virtualization.** KVM Nested paging

▶ *Student comments after the course*

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